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14. ABSTRACT

This project conducted detailed studies on the 6 April 2000 superstorm and on the 25 September 1998 great storm. These studies produced significant results including an analysis on the model performance of CTIPe (Coupled Thermosphere-Ionosphere-Plasmasphere Electrodynamics). The 6 April 2000 superstorm (Dst = -314 nT) was complex as the prompt penetration electric field developed and operated under continuous disturbance dynamo electric field effects. Thus, this storm offered the opportunity to study the impact of eastward PPEF on the daytime Equatorial Ionization Anomaly (EIA) while the disturbance dynamo continued. The 25 September 1998 great storm (Dst = -220 nT) was a unique event because of its unusual pattern producing unusual ionospheric storms. Our results reveal some strong longitudinal differences caused by the domination of eastward (westward) perturbation **E**-fields in the Australian (Indian) sector causing the presence (absence) of the EIA that was reasonably well reproduced by CTIPe.

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FINAL REPORT

During this 10-month project (AOARD-13-4090; FA2386-13-1-4090), we have conducted detailed studies on the 6 April 2000 superstorm and on the 25 September 1998 great storm. Their findings are published already or will be published soon with JGR Space Physics. These studies produced significant scientific results including an analysis on the model performance of CTIPe (Coupled Thermosphere-Ionosphere-Plasmasphere Electrodynamics). In this report, some significant findings are highlighted.

The 6 April 2000 superstorm (D_{st} = -314 nT) was complex as the prompt penetration electric field (PPEF) developed and operated under continuous disturbance dynamo electric field (DDEF) effects. Thus, this storm offered the opportunity to study the impact of eastward PPEF on the daytime Equatorial Ionization Anomaly (EIA) while the disturbance dynamo continued. We have utilized field-aligned and multi-instrument observations demonstrating a repeated EIA development. While the eastward PPEF strengthened the forward fountain into a super-fountain and created two well-developed EIA crests, the westward DDEF caused the development of a broad EIA trough region. CTIPe could reproduce these EIA features but only during 0015-0050UT on the following day, 7 April. We have identified the signature of this westward DDEF both in the vertical plasma drifts and plasma flows appearing as local (i.e. over the dip equator) depletions, and in the plasma composition appearing as a locally reduced [O^+] fraction and increased [H^+] fraction (see details in Horvath and Lovell, 2013).

Some large plasma density enhancements developed during the 6 April 2000 superstorm. Our study is focused on the northern polar cap region. It demonstrates the development of large Polar Cap Enhancements (PCEs) over the North American continent in the evening sector with lifetimes of ~7 hours and with magnitudes six times greater than the quiet-time plasma densities. Regarding their development, our results reveal that these long-lasting PCEs occurred due to the repeated strengthening of SAPS (Sub-Auroral Polarization Stream) electric (**E**) fields, which were triggered by a series of increases in magnetic convection **E**-field, as suggested by the increased polar cap potential (PCP) drops, causing repeated plasmaspheric erosion events that in turn provided a continuous supply of cold storm-enhanced density (SED) plume plasma. We have computed PCP values (Φ_{PC}; kV) by utilizing the 15-min polar cap north index (PCN; mV/m) from Thula (290.83^{o}E, 77.48^{o}N (geographic); 87.68^{o}N (geomagnetic)) as Φ_{PC} (kV)=19.35PCN+8.78 and modelled this strong SAPS-PCP correspondence during 1600-1759MLT as SAPS $V_{Y(peak)}$ [m/s]=6.54 [(m/s)/kV]×Φ_{PC} [kV]+498.73 [m/s]. Although these modelling results are specific to the 6 April 2000 superstorm, they add to our current understanding of PCP-SAPS **E**-field connection and prolonged maintenance of PCEs. An interesting feature observed was the segmentation of a large PCE forming a polar tongue of ionization (TOI) across the magnetic North Pole. Plasma flow observations, made in the vertical and horizontal directions, suggest that slow plasma convection and flow stagnation caused the plasma segmentation observed in the regions of auroral zone and polar cap respectively (see details in Horvath and Lovell, 2014a).

The 25 September 1998 great storm (D_{st} = -220 nT) was a unique event because of its unusual pattern producing unusual ionospheric storms. Our results reveal some strong longitudinal differences caused by the domination of eastward (westward) perturbation **E**-fields in the Australian (Indian) sector causing the presence (absence) of the EIA that was reasonably well reproduced by CTIPe. In the Australian sector, the eastward PPEFs exhibited a strong positive correlation with the variations of both the PCP drop and the asymmetric ring current (ASY-H) during the sub-storm series occurring in the storm recovery phase. These eastward PPEFs significantly increased the net equatorial upward **E×B** drift and thus caused the repeated development of the EIA with plasma bubbles scintillating GPS signals (±0.5 ΔTECU/min). We have correlated these scintillation events with the periodic asymmetric ring current intensification episodes. Significant for modeling purposes, our observational results demonstrate the suitability of ASY-H index acting as a good indicator of both EIA development and GPS signal scintillation during intense eastward electrojet events (see details in Horvath and Lovell, 2014b).

Publications:

Horvath, I., and B. C. Lovell (2013), Equatorial westward electrojet impacting equatorial ionization anomaly development during the 6 April 2000 superstorm, *J. Geophys. Res*., *Space Physics*, 118, doi:10.1002/2013JA019311.

Horvath, I., and B. C. Lovell (2014a), Large plasma density enhancements occurring in the northern polar region during the 6 April 2000 superstorm, *J. Geophys. Res., Space Physics*, 119, 4805–4818, doi:10.1002/2014JA019917.

Horvath, I., and B. C. Lovell (2014b), Perturbation electric fields and disturbance currents investigated during the 25 September 1998 great storm, *J. Geophys. Res., Space Physics*, (under review).